

FUNDAMENTAL SPACE BIOLOGY

Dietary Salt Sensitivity and Bone in a Spaceflight Model

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It is well known that the amount of salt in the diet affects blood pressure. Eight to thirty percent of patients who develop hypertension can be described as "salt-sensitive" because they manifest high blood pressure when consuming salt-rich diets. High salt diets affect not only the cardiovascular system but are also thought to worsen osteoporosis unless the amount of calcium in the diet is also relatively high. This is because there is an obligatory excretion of calcium in amounts proportional to the amount of sodium in the diet. Using a rat model for human hypertension (the Dahl salt-sensitive and salt-resistant strains), Dr. Thierry-Palmer from the Morehouse School of Medicine has found no differences in the amount of calcium excreted in the urine that seemed to relate to the level of dietary salt, but has found some differences in vitamin D metabolism magnified by the level of dietary salt. Vitamin D is a component of the calcium endocrine system that functions to facilitate the transport of calcium in and out of the kidney, intestine, and bone. In the absence of differences in the renal handling of calcium, we collaborated to explore the possibility that the vitamin D abnormalities might be connected to some differences in bone.

Static and dynamic studies were made of the femurs in Dahl salt-sensitive and salt-resistant rats. The static studies involved measurements of mineral content and strength in the bones of animals fed normal amounts of dietary salt (0.4%). No differences were found in the mineral content or strength of bones from salt-

sensitive or salt-resistant male or female juvenile rats. The dynamic studies used the same measurements to evaluate the responses of bone to a spaceflight model in female rats fed high or low levels of dietary salt. Females were studied because the vitamin D differences were found in females only. Salt-sensitive rats tended to grow more rapidly than salt-resistant animals and weighed more than the resistant species. Given that bone mineral content of weight-bearing bones is related to body weight, the values in the salt-sensitive animals tended to be higher than in the salt-resistant animals. This additional mineral in the larger rats did not influence the response to skeletal unloading. Unloaded femurs showed 9% decreases in sensitive and 10% decreases in the resistant forms. The responses in femoral strength are illustrated in figure 1 on the next page. It shows the results of torsion testing of femurs with an instrument developed by T. Cleek and R. Whalen. Torque, Newton-meters squared (Nm^2), was consistently less in the femurs unloaded for 4 weeks than in the femurs bearing normal body weight. There were no observable differences between the salt-sensitive and salt-resistant juveniles. We plan to continue these observations in mature females. For the present we have been unable to connect the differences in vitamin D metabolism with a specific bone response in male or female juveniles of the species.

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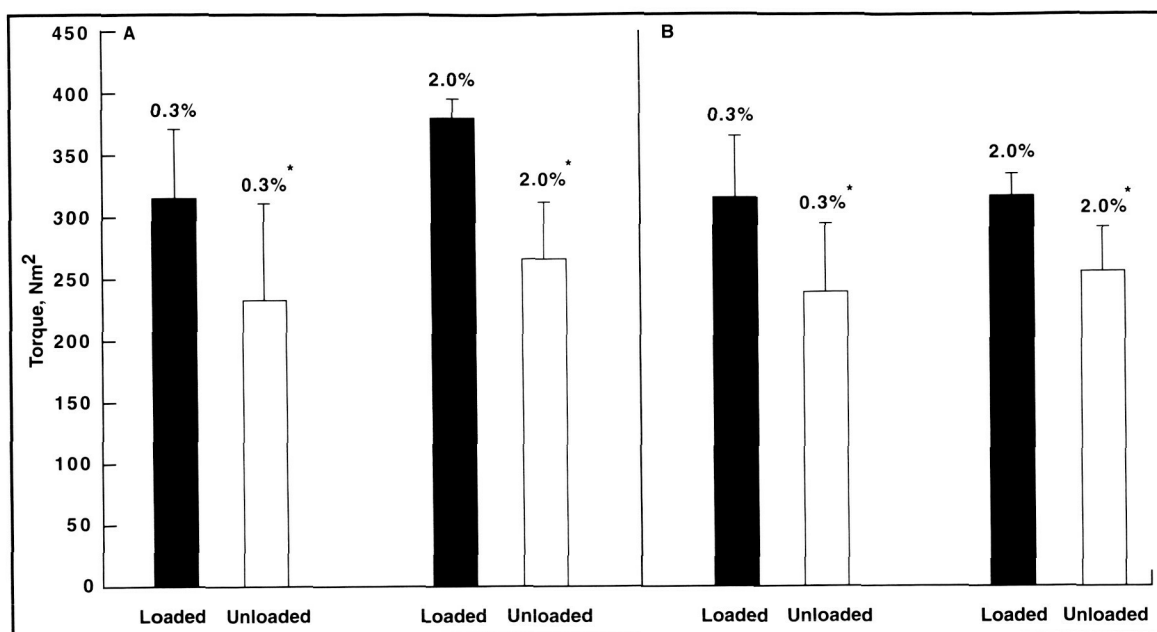


Fig. 1. The results of torsion testing of the left femur after either 4 weeks of ambulation or 4 weeks of unloading in a spaceflight simulation model in rats fed either 0.3% (low) or 2% (high) levels of dietary salt. Panel A shows the results in the Dahl salt-sensitive rats with body weights averaging 238 grams (gr), and panel B shows the results in Dahl salt-resistant rats with body weights averaging 200 grams. The asterisk indicates statistically significant differences at $p < 0.05$. There do not appear to be differences in the response of femurs of salt-sensitive and salt-resistant rats to unloading.

Effect of Age and Activity Level on Bone Mass and Distribution

Tammy Cleek, Robert Whalen

The objective of this study was to gain a better understanding of the relationship between age, activity level (as indicated by runners and non-runners), and site specific bone mass and long bone structural parameters related to long bone cross-sectional geometry. We hypothesized that bone mass measurements and long bone structural properties would be decreased with age but would be enhanced by a higher activity level.

Currently, the most widely used and accepted method of noninvasive skeletal assessment is dual energy x-ray absorptiometry (DXA) which measures regional and whole body changes in bone mineral content (BMC) and areal bone mineral density (BMD). However,

whole bone stiffness and strength are not solely dependent on bone mass, but also upon its cross-sectional shape and distribution.

Bone densitometry has been previously used to obtain cross-sectional properties of bone in a single scan plane. In a new approach using three noncoplanar scans, this technique was extended to obtain the principal moments of inertia and orientations of the principal axes of each scan cross-section. This method has been validated using aluminum phantoms and cadaveric long bones. The method was used in this study to investigate structural properties in the long bones of the lower limb as a function of age and activity level in women.